CHAPTER 3

AFFECTED ENVIRONMENT, SIGNIFICANT IMPACTS, MITIGATION MEASURES AND SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

INTRODUCTION

This chapter describes the affected environment, significant impacts of the Proposed Actions and alternatives, relevant mitigation measures, cumulative impacts and significant unavoidable adverse impacts. For each element of the environment, impacts are discussed for the Proposed Actions and alternatives. Mitigation measures described in this chapter are "required/proposed" measures that would mitigate identified significant adverse impacts or "other possible" measures that could further reduce impacts, but are not required to reduce potential impacts to non-significant levels.

The proposal for RRE described in the February 2003, RRE permit application included 85 to 90 percent, or 710 to 730, single-family housing units, and 10 to 15 percent, or 70 to 90, multifamily housing units. Since that time, the RRE proposal has been revised to include approximately 83 percent, or 665, single-family housing units, and approximately 17 percent, or 135, multifamily housing units. **Chapter 2** of this Draft EIS provides a detailed description on the current proposal. The **Noise**, **Land Use**, **Relationship to Plans and Policies**, **Aesthetics/Light and Glare**, and **Public Services and Facilities** sections in **Chapter 3** of this Draft EIS analyze the potential impacts of the current proposal. The other sections of **Chapter 3** that are based on technical analyses (i.e., **Earth, Water**, **Plants and Animals**, **Wetlands**, **Transportation** and **Utilities**) analyze the potential impacts of the original proposal and were not updated to account for the current proposal. The assumptions upon which the technical analyses were based were considered conservative and allowed for the subsequent adjustment to the housing mix. Therefore, King County determined that it was not necessary to update these analyses. See **Appendices A**, **B**, **C**, **D**, **E**, and **F** for further descriptions of the assumptions used for the analyses.

EARTH

INTRODUCTION

Discussion of earth-related conditions on the RRE and Panhandle sites and in the vicinity of the sites is based on the Environmental Impact Statement Technical Report on Geology, Soils and Groundwater (March, 2004) prepared by Associated Earth Sciences (see **Appendix A**).

AFFECTED ENVIRONMENT

Geologic conditions at the RRE and Panhandle sites were evaluated using data obtained from: 1) fieldwork for this EIS; 2) previous studies on the Redmond Ridge and Trilogy UPD projects; 3) previous studies for the RRE and Panhandle sites; and 4) regional geologic maps and documents (see **Appendix A** for details).

Topography

The RRE and Panhandle sites are located on the Bear Creek plateau, which is bounded to the east by the Snoqualmie River Valley, to the west by the Bear Creek Valley, and partially to the south by the Evans Creek and Patterson Creek Valleys. Topographic features in the vicinity of the sites were formed by glacial and postglacial processes. Elongate northwest-southeast trending hills and swales parallel the flow direction of an ice sheet that occupied the Puget Lowland about 15,000 years ago.

The topography of the RRE and Panhandle sites is generally gently rolling; steeper slopes are located on the eastern portion of the Panhandle site. Areas of poor or restricted drainage occur in the swales between low hills. Elevations on the RRE site range from about 525 feet near the northeastern corner of the site to about 605 feet along the site's southern boundary. On the Panhandle site, elevations generally range from about 550 to 600 feet. The exception to this exists along the far eastern portion of the Panhandle site, where elevation drops rapidly (from about elevation 550 feet to 380 feet) near the top of the steep slopes of the western wall of the Snoqualmie River Valley (see **Figure 2** for the existing conditions on the sites, including topography).

Regional Geology

The Bear Creek plateau is underlain by deposits associated with multiple glaciations and nonglacial intervals resulting in a complex stratigraphic framework. Geologic mapping of the Bear Creek Plateau and surrounding areas presumed that most of the Quaternary deposits exposed along the steep slopes of the plateau, and interpreted to lie under the majority of the plateau, are Olympia or younger in age. However, geologic exploration on and surrounding the Bear Creek Plateau has identified several outcrops where the stratigraphy indicates that deposits older than the Olympia nonglacial interval underlie the plateau at relatively high elevations (see **Appendix A** for further information on regional geology).

Site Geology

Figure 10 in **Appendix A** shows the surficial geology of the RRE and Panhandle site. Cross sections summarizing surface and subsurface geology relative to site topography are presented in Figures 11 to 14 in **Appendix A**. The locations of the cross sections are shown in Figure 6 in **Appendix A**.

Five geologic units on and in the vicinity of the RRE and Panhandle sites were identified. These include: pre-Possession-age, Possession, Olympia nonglacial, Vashon Stade and Recent deposits. These five geologic units have been sub-divided into eight stratigraphic units: fine-grained pre-Possession-age (Qppf), coarse-grained pre-Possession-age (Qppc), Pepper Creek diamict (Qpd), Olympia nonglacial deposits (Qo), Vashon advance outwash (Qva), Vashon lodgment till (Qvt), Vashon recessional outwash (Qvr) and Recent alluvium (Qa) (see **Appendix A** for further description of the site geology).

Surface Soils

Physical and chemical weathering of surficial glacial deposits has resulted in the formation of various types of surface soils on the RRE and Panhandle sites. Surface soils data were obtained from the SCS soil survey of King County. **Figure 16** shows surface soils on the RRE and Panhandle sites, based on the SCS mapping and modified by site-specific subsurface investigations and slope mapping performed for this EIS (see **Appendix A** for further information on surface soils).

The five factors typically used to define the type, characteristics, and formation of specific soils are: 1) parent material; 2) climate; 3) topography; 4) organisms (biota); and 5) time. The soils of the project sites formed over young glacial deposits and have not had sufficient time to develop the deep weathering profiles present in soils in unglaciated terrains. Instead, they exhibit a direct relationship to the underlying parent material, local climate, topography, and vegetation.

The soil characteristics of the soils found on the RRE and Panhandle sites are summarized in **Table 8** below, and are described in greater detail in the following sections.

Table 8
SUMMARY OF RRE AND PANHANDLE SOIL TYPES

Soil Name	USDA Textural Classification	Percent Slope	Runoff Rate	Erosion Hazard
Alderwood (AgC)	Gravelly Loam	6 to 15	Slow to medium	Moderate
Alderwood (AgD)	Gravelly Sandy Loam	15 to 30	Medium	Severe
Alderwood and Kitsap (AkF)	Gravelly Sandy / Silt Loam	Greater than 40	Rapid to very rapid	Severe to very severe
Orcas Peat (Or)	Peat	0 to 1	Ponded	None
Seattle Muck (Sk)	Muck	Less than 1	Ponded	None

Source: AESI, 2004.
USDA = U.S. Department of Agriculture; see **Figure 16** for the soils map.

Soil Units

<u>Alderwood Series.</u> The Alderwood Series (AgC and AgD) is composed of moderately well drained soils having a strongly consolidated substratum. These soils are characterized by dark-brown and grayish brown, gravelly, sandy loam developed over a substratum of grayish brown, glacially consolidated lodgment till.

Permeability in the Alderwood Series is moderately rapid in the surface layer and subsoil, becoming very slow to nil in the underlying lodgment till, where groundwater has a tendency to perch and form an interflow groundwater regime during winter months. Runoff is slow to medium, and the erosion hazard is moderate for sheet flow and low to moderate for concentrated flow. The Alderwood Gravelly Loam (AgC) is the dominant soil type found on the RRE and Panhandle sites (see **Figure 16**). Alderwood Gravelly Sandy Loam (AgD) is present on the steeper portions of the Panhandle site, uphill from the very steep slopes above West Snoqualmie Valley Road. The physical characteristics of this soil are similar to AgC; however, the erosion potential is higher due to the steeper slopes (see the Erosion Hazards discussion below).

Figure 16
Surficial Soils

Alderwood and Kitsap. The Alderwood and Kitsap soils (AkF) are about 50 percent Alderwood Gravelly Sandy Loam and 25 percent Kitsap Silt Loam. Distribution of the soils varies greatly within short distances. About 15 percent of some mapped areas are unnamed, very deep, moderately coarse textured soil; and about 10 percent of some areas are a very deep, coarse textured Indianola soil. Drainage and permeability vary. Runoff is rapid to very rapid, and the erosion hazard is severe to very severe. The SCS classifies the slippage potential as severe. This soil type is found on the easternmost portion of the Panhandle site, and is found along the steep slopes above West Snoqualmie Valley Road (see **Figure 16**).

Orcas Peat. Orcas Peat (Or) is composed of poorly drained soils that formed in sphagnum moss and small amounts of Labrador tea and cranberry plants. These soils are in basins on the undulating, rolling glacial uplands, and are characterized by dark reddish brown sphagnum peat over yellowish red sphagnum peat that extends to a depth of about 60 inches. Permeability in the Orcas Peat is very rapid. Runoff is ponded and there is no erosion hazard. This soil type is found on the RRE site in Wetland BBC 52 and to the west on the Redmond Ridge UPD site (see **Figure 16**).

Seattle Muck. Seattle Muck (Sk) is composed of very poorly drained organic soils that formed in material derived primarily from sedges. These soils are in depressions and valleys on the glacial till plain and also in the river and stream valleys. These soils are characterized by black muck underlain by dark reddish brown, black, very dark brown, and dark brown muck and mucky peat. Permeability in the Seattle Muck is moderate. Runoff ponds, and there is no erosion hazard. This soil type is found in large wetland areas on the RRE site and to the west on the Redmond Ridge UPD site (see **Figure 16**).

Geologic Hazards

Erosion Hazards

Erosion hazard areas are identified by King County Code 21A.06.415 as *"those areas in King County underlain by soils which are subject to severe erosion when disturbed. Such soils include, but are not limited to, those classified as having a severe to very severe erosion hazard according to the USDA Soil Conservation Service, the 1990 Snoqualmie Pass Area Soil Survey, the 1973 King County Soils Survey or any subsequent revisions or addition by or to these sources. These soils include, but are not limited to, any occurrence of River Wash ("Rh") or Coastal Beaches ("Cb") and the following when they occur on slopes 15% or greater:*

A. The Alderwood gravelly sandy loam ("AgD");
B. The Alderwood and Kitsap soils ("AkF");
C. The Kitsap silt loam ("KpD");
D. The Ovall gravelly loam ("OvD" and "OvF");
E. The Ragner fine sandy loam ("Rad"); and
F. The Ragner-Indianola Association ("RdE")."

Based on these criteria, erosion hazard areas on the RRE and Panhandle sites generally coincide with slopes of 15 percent or steeper. It is important to understand where and how erosion occurs. Sediment begins motion by a process called gross erosion that can be subdivided into sheet erosion and channel erosion.

Sheet erosion is caused by shallow "sheets" of water flowing over the cleared land surface and transporting soil particles that have been detached by raindrops. The shallow surface flow rarely moves as a uniform sheet for more than a few feet before concentrating in surface irregularities and resulting in rill erosion. Additional sediment is thus picked up and transported. This erosion process is continuous over several storm or normal rainfall events. Rainfall from storms tends to concentrate in established paths; however, once the rill is disrupted, for example by falling leaves or small branches, the rill path is disrupted and the rill erosion will take place elsewhere. If the rills become more than a few inches deep, then the erosive regime changes to gully (channel) erosion where concentrated water flow can transport large quantities of sediment during a single storm event; this usually occurs on slopes greater than 15 percent.

Different soil types and geologic parent material can have widely differing susceptibilities to each erosive regime. Slope gradients and vegetation play an important role in determining erosion impacts. In general, steeper slopes have a higher susceptibility to erosion as surface water has the capability of achieving higher velocities and, hence, has more energy available to erode and transport sediments. Vegetation, on the other hand, has a tendency to reduce the potential development of concentrated flows by dispersing rainfall, impeding surface water flow, and reducing surface water velocities.

Based on existing erosion occurrence on the RRE and Panhandle sites, sediment characteristics, and slope gradients, the RRE and Panhandle sites have been divided into three hazard classifications, as shown in **Figure 17** and described in **Table 9**. The RRE site is encompassed entirely by Erosion Hazard Zone 1, Low to Moderate Erosion Risk. The majority of the Panhandle site is also in Erosion Hazard Zone 1. The exception occurs on the easternmost portion of the Panhandle site, where Erosion Hazard Zone 2 and 3 areas exist.

Table 9
EROSION HAZARD ZONES DESCRIPTION

Hazard Zone	Description
Erosion Hazard Zone 1	Low to moderate erosion hazard risk. Typically contain slopes of less than 15 percent and underlain by soils defined by SCS as having a slight erosion risk. Does not fall under the King County definition of an Erosion Hazard Area.*
Erosion Hazard Zone 2	High erosion hazard risk. Typically contain slopes greater than 15 percent and are underlain by soils that have a severe to very severe erosion risk. Falls under the King County definition of an Erosion Hazard Area.*
Erosion Hazard Zone 3	Severe to very severe erosion hazard risk. Typically contain slopes greater than 40 percent and/or are underlain by soils defined by the SCS as having a severe erosion potential. Falls under the King County definition of an Erosion Hazard Area.*

Source: AESI, 2004.
*King County Code 21A.06.415; see **Figure 17** for erosion hazard mapping.

Figure 17
Erosion Hazards

Landslide and Steep Slope Hazards

Landslide hazard areas are defined in Chapter 21A.06.680 of the King County Code as "*those areas in King County subject to severe risks of landslides, including the following:*

A. Any area with a combination of:
   1) Slopes steeper than 15 percent;
   2) Impermeable soils, such as silt and clay, frequently interbedded with granular soils, such as sand and gravel; and
   3) Springs or groundwater seepage

B. Any area which has shown movement during the Holocene epoch, from 10,000 years ago to the present, or which is underlain by mass wastage debris from that epoch;

C. Any area potentially unstable as a result of rapid stream incision, stream bank erosion or undercutting by wave action;

D. Any area which shows evidence of or is at risk from snow avalanches; or

E. Any area located on an alluvial fan, presently subject to or potentially subject to inundation by debris flows or deposition of stream-transported sediments."

Landslide hazard areas are located on the easternmost portion of the Panhandle site, per the above definition, and are mapped in the King County Sensitive Areas Folio (1990) off-site on the steep east-facing slopes adjacent to the West Snoqualmie Valley Road; none are mapped on the RRE site.

Steep slope hazard areas are defined in King County Code 21A.06.1230 as "*those areas in King County on slopes 40 percent or steeper within a vertical elevation change of at least 10 feet. A slope is delineated by establishing its toe and top, and is measured by averaging the inclination over at least 10 feet of vertical relief. For the purpose of this definition:*

A. The toe of a slope is a distinct topographic break in slope which separates slopes inclined at less than 40% from slopes 40% or steeper. Where no distinct break exists, the toe of a steep slope is the lower most limit of the area where the ground surface drops ten feet or more vertically within a horizontal distance of 25 feet; and

B. The top of slope is a distinct, topographic break in slope which separates slopes inclined at less than 40% from slopes 40% or steeper. Where no distinct break exists, the top of a steep slope is the upper most limit of the area where the ground surface drops ten feet or more vertically within a horizontal distance of 25 feet."

Steep slopes (40 percent or greater) are located on the easternmost portion of the Panhandle site and off site on the east-facing valley wall above the Snoqualmie River Valley.

An analysis of the existing landslide and steep slope hazard potential on the RRE and Panhandle sites was conducted to identify landslide and steep slope hazard areas. Hazard risks were subdivided into two categories, as described in **Table 10** and shown in **Figure 18**. Landslide Hazard Zone 1 typically incorporates slopes of less than 40 percent with low landslide hazard risk. Landslide Hazard Zone 2 typically incorporates steep slope areas (over 40 percent slopes) with high landslide risk. The RRE site is encompassed entirely by Landslide Hazard

Zone 1, Low Landslide Hazard risk. The majority of the Panhandle site is in Landslide Hazard Zone 1. The exception is the easternmost portion of the Panhandle, where Landslide Hazard Zone 2 areas exist.

Table 10
LANDSLIDE HAZARD ZONES DESCRIPTIONS

Landslide Hazard Zone	Description
Landslide Hazard Zone 1	Low landslide hazard risk. Typically include slopes of less than 40 percent. No evidence of past or recent landslide activity, groundwater seepages, or adverse geologic conditions.
Landslide Hazard Zone 2	High landslide hazard risk. Typically includes slopes greater than 40 percent containing evidence of past or recent landslide activity, groundwater seepages and adverse geologic conditions. Falls under the King County definition of a Steep Slope Area and a Landslide Hazard Area.*

Source: AESI, 2004.
*King County Code 21A.06.680 and 21A.06.1230; see **Figure 18** for landslide hazard mapping.

Generally, there are two types of landslides that commonly occur in the Puget Sound region. The first type is termed earth slump or slump-earth flow. This type of earth movement is deep seated and usually involves the regolith (topsoil and weathered zone) and the underlying sedimentary units. Slides of this type can be very large and may require costly stabilization measures. The second type is termed debris slump or debris flow and usually involves the upper few feet of the regolith. This type of slide is very dependent on the moisture content and weathering characteristics of the sediment. Slides of this type are typically triggered by groundwater seepages, oversteepening of the banks by stream erosion, or movement of saturated sediments on steep slopes. No evidence of landslides was found on the RRE and Panhandle sites. Indications of landslides were found in several of the off-site streams located on the east-facing slopes adjacent to the West Snoqualmie Valley Road.

Channel Erosion

An erosion and sedimentation analysis was conducted for Unnamed Creek (07-0276), 07-0277, 07-0277A, Pepper Creek (SR-5), SR-5A, SR-5D, AC-2, AC-2A and AC-4 off-site. The headwaters to Unnamed Creek, Pepper Creek, SR-5D and AC-4 are formed in wetlands on the RRE and/or Panhandle sites. The purpose of this analysis was to identify existing erosion and sediment transport hazards in selected drainage channels that originate near the sites and that receive surface water from on-site headwater wetlands. The intermittent onsite streams, which include the entire length of BBC-52 tributary, BBC-53 tributary, and HH/BBC-54 tributary, a portion of VS-17 tributary, and potentially small portions of VS-24 tributary and EE/VS-31 tributary), were not included in this analysis because the Proposed Actions would involve no changes in discharge to them (see **Appendix A** for details). The analysis included performing a visual, geologic reconnaissance of off-site drainage channels. An analysis of flood-frequency curves, flow duration distributions, and storm hydrographs was conducted for selected stream

Figure 18
Landslide Hazards

channels based on Hydrologic Simulation Program Fortran (HSPF) modeling (see **Appendix A** for details on the erosion sedimentation analysis and the **Water** section and **Appendix C** for details on the HSPF modeling).

<u>Channel Erosion Processes.</u> The capacity of a stream to erode and transport sediment is generally a balance between stream gradient, flow rate, channel geometry, roughness of the streambed (woody debris, boulders), and pavement gravel size. A change in one of these variables by large storm events, floods, landslides, or by development activities (grading, stormwater release, or clearing operations) can increase or decrease the existing erosion and sediment transport hazards of the stream (see **Appendix A** for additional information on channel erosion processes).

<u>Channel Geomorphology.</u> An analysis of channel geomorphology was conducted for select identified basins located on and around the RRE and Panhandles sites, including the Unnamed Creek basin, Pepper Creek basin, and the Ames Creek tributaries. Channel gradients, drainage, and erosion thresholds were analyzed (see **Appendix A** for details on channel geomorphology).

Unnamed Creek (07-0276), the primary stream in the Unnamed Creek basin, has several existing landslides and other erosion features, especially in the upper portion of the mainstem from downstream of the 243rd Avenue NE crossing to the confluence with Tributary 07-0277. In general, the lower main stem has a shallower gradient and meanders within a broad "U" shaped valley; however, a few older landslides, mainly revegetated, contribute sediment to the stream. Tributaries 07-0277 and 07-0277A also have several landslide features and are actively incising. A small portion of RRE (approximately 6 acres of the SRN-2 basin, as shown on Figure 3 in **Appendix A**) drains to 07-0277A (which begins approximately 500 feet east of the northeast property boundary of RRE) via a road ditch along 244th Avenue NE where the flow accumulates in a topographic low until it sheet flows across 244th Avenue NE to the NE 112th Street ditch; however, the majority of runoff to 07-0277A is from off-site residential development and roads. Due to a largely uncontrolled surface water runoff from rural residential development in the contributing drainage basin, 07-0277A has evolved to a significant erosional ravine. Tributaries 07-0277 and 07-0277A would be susceptible to additional stream incision, sidebank destabilization, and channel degradation as a result of uncontrolled stormwater discharge (see **Appendix A** for details on the stream channel survey).

Pepper Creek (SR-5), which begins in on-site wetlands VS 17 and VS 35 on the southeastern portion of RRE and the northwestern portion of the Panhandle, is the primary stream in the Pepper Creek basin. Pepper Creek has several existing landslides and other erosion features, especially in the upper portion of the mainstem beginning about 70 feet downstream of 248th Avenue NE to about 300 feet upstream of the SR-5A confluence. Tributaries SR-5A and SR-5D also have several landslide features and are actively incising. The channels would be susceptible to additional stream incision, sidebank destabilization, and channel degradation as a result of uncontrolled stormwater discharge. Historically, Pepper Creek has experienced very severe erosion and transported very large amounts of sediment to the Snoqualmie River Valley floor (see **Appendix A** for details on the stream channel survey). Specifically, following the November 1986 rain storms, Pepper Creek deposited approximately 7 feet of sand and gravel over the West Snoqualmie Valley Road and adjacent private property, causing a road closure for over a day and filling in low areas in the downstream flood plain of the Snoqualmie River.

Three Ames Creek tributaries are located in close proximity to the Panhandle site: AC-2, AC-2A and AC-4. Ames Creek tributaries AC-2 and AC-2A do not receive any direct surface water runoff under existing conditions from the RRE and Panhandle sites. AC-2 and AC-2A begin approximately 200 to 300 feet down slope from the eastern boundary of the Panhandle site at a spring discharge zone from a pre-Possession-age aquifer that receives recharge from the RRE site and the majority of the Panhandle site. Wetlands VS 12 and VS 13 on the Panhandle site form the headwaters of AC-4. AC-4 is relatively stable in the upper portion of the channel. Downstream of approximate elevation 450 feet (approximately 1,500 feet downstream from the 258th Avenue NE crossing) several landslides and other erosion features were present. The channel would be susceptible to stream incision, sidebank destabilization, and channel degradation as a result of uncontrolled stormwater discharge (see **Appendix A** for details on the stream channel survey).

Five intermittent (ephemeral during years of normal rain flow) streams are present on the RRE site and two intermittent streams are present on the Panhandle site (both of these counts include VS-17 trib, a portion of which is located on each site). These streams are formed by wetland discharge, and would be susceptible to erosion (see the **Water** section for more information). The streams are depicted in **Figure 22** and in **Appendices C** and **E**. No streams were scoped to require gauging in the MDP. Wetland water analysis is provided in Section 8 of the MDP (see **Appendix C**).

Seismic Hazards

Seismic hazard areas are defined in Chapter 21A.06.1045 of the King County Code as *"those areas in King County subject to severe risk of earthquake damage as a result of soil liquefaction in areas underlain by cohesionless soils of low density and usually in association with a shallow groundwater table or of other seismically induced settlement."*

The RRE and the Panhandle sites are located in an area of low to moderate historical seismicity. Table 4-6 in **Appendix A** summarizes historical and recorded seismic events greater than magnitude (M) 3.0 in the vicinity of the sites as obtained from the University of Washington's Pacific Northwest Seismograph Network (see **Appendix A** for additional information on historical seismicity information).

The three largest earthquakes, ranging from M 5.0 to M 5.7, were located within a 15-mile radius of the site. Two of these earthquakes occurred prior to the operation of the Pacific Northwest Seismograph Network in 1970, and data concerning the magnitudes, locations, and depths are less precise. The third event (1996) occurred approximately 15 miles northeast of the sites and is the largest seismic event recorded in the sites' vicinity since the installation of the Pacific Northwest Seismograph Network.

Surficial Fault Zones. The Seattle Fault is a 4- to 6-kilometer-wide zone of three or more active faults. The west-trending fault zone has been mapped in waterways from Dyes Inlet to Lake Washington. A recent exposure of the fault was excavated in Bellevue, Washington approximately 8 miles southwest of the RRE and Panhandle sites. This is the easternmost exposure found. The South Whidbey Island Fault is a largely unexposed fault extending from Vancouver Island southeast toward the Cascade Range. There is evidence that there has been recent offset and deformation along the fault and the fault is considered to be active and capable of generating large earthquakes, representing a potential seismic hazard to residents. The fault is mapped from the eastern Strait of Juan de Fuca to Possession Sound (near Everett) and is projected to extend southeast to the Cascade Range in the vicinity of the RRE and Panhandle sites (see **Appendix A** for more information on these faults).

No evidence of surface faults or associated ground ruptures was observed at the RRE and Panhandle sites and the risk of surface rupture impacting the sites is considered to be low.

Four types of potential geologic hazards are usually associated with large seismic events: ground rupture along a surficial fault zone; ground motion response; liquefaction; and seismically induced landslides.

Ground Motion Response. Ground motion from an earthquake results from shear, pressure, and surface waves propagating through the earth's crust from the earthquake's hypocenter. The ground motion caused by these waves is the seismic shaking felt during an earthquake. The intensity of the shaking felt at a given location during and immediately after an earthquake, is a result of several variables including: 1) the magnitude of the earthquake; 2) distance from the earthquake; 3) depth of the earthquake; 4) the type of rocks and unconsolidated sediments underlying a given site; and 5) attenuation of the seismic energy between the earthquake and a given site. Although the RRE and Panhandle sites are located in an area of relatively low to moderate historical seismicity, there are several sources of large earthquakes in western Washington that are capable of generating significant earthquakes, as discussed above

The USGS has created seismic hazard maps to predict the expected peak ground acceleration from earthquakes. According to this work, in the next 50 years there is a 10 percent chance that ground motions will exceed 30 percent acceleration of gravity (g) in the vicinity of the RRE and Panhandle sites. This work contributed to the Uniform Building Code (UBC) determinations of seismic zones in the Pacific Northwest. The RRE and Panhandle sites are located within Seismic Zone 3 of the 1997 UBC. The seismic zones used by the UBC range from Seismic Zone 0 (area of low seismic risk) to Seismic Zone 4 (area of high seismic risk). The UBC's seismic zone classifications are used to determine the strengths of various components of a building or structure needed to resist earthquake damage caused by ground motion. Design guidelines for minimizing earthquake damage to structures based on anticipated ground motions for a specific region are included in the UBC.

Unconsolidated young deposits may amplify ground motion, and ground motions in these areas will likely be more intense than predicted for sites underlain by bedrock or glacially consolidated materials. The RRE and Panhandle sites are underlain by dense material, with the exception of wetlands, stream corridors, and uncontrolled fills (present as logging roads, powerline roads, and railroad grades), and the risk of ground rupture is interpreted to be low.

Liquefaction. Liquefaction is the process in which soil loses strength or stiffness during vibratory shaking, such as that caused by earthquakes, and temporarily behaves as a liquid. Shaking during an earthquake can cause an increase in pore water pressure in the soil, and decrease the soil shear strength. Soils are considered to liquefy when nearly all of the weight of the soil is supported by the pore water pressure and becomes relatively unstable. The seismically induced loss of soil strength can result in failure of the ground surface and can be expressed as landslides or lateral spreads, surface cracks and settlement, and/or sand boils. Seismically induced liquefaction typically occurs in loose, saturated, non-cohesive sandy and silty soils commonly associated with recent river, lake, and beach sedimentation. In addition, seismically induced liquefaction can be associated with areas of loose, saturated fill.

Unconsolidated soils underlying wetlands and stream corridors may be susceptible to liquefaction during larger seismic events, although most of the susceptible soil layers are likely relatively thin. Based on the results of the field exploration program on the RRE and Panhandle sites, experience with similar soil types, and an understanding of the regional seismicity, the potential for liquefaction of the soils underlying the RRE and Panhandle sites is low.

Seismically Induced Landslides. Earthquake vibration may cause unstable material to fail by influencing existing planes of weakness within bedrock (such as bedding planes or fault planes) or within unconsolidated material. No evidence of seismically induced landslides has been observed on the RRE and Panhandle sites. The risk of seismically induced landslides occurring is interpreted to be low across all of the RRE site and most of the Panhandle site. The risk would be higher along the easternmost portion of the Panhandle where slopes exceed 40 percent. These areas are mapped as Landslide Hazard Zone 2 (see **Figure 18**).

SIGNIFICANT IMPACTS OF THE PROPOSED ACTIONS

The RRE and the Panhandle Proposed Actions would require grading to achieve desired roadway, driveway, and building pad elevations. Preliminary grading plans indicate that approximately 1.5 million cubic yards of earthwork would be required through project buildout of RRE and 15,000 to 50,000 cubic yard of earthwork would be required through buildout of the Panhandle (see **Chapter 2** for further information on proposed grading). The geotechnical explorations and analysis completed for the RRE and Panhandle projects indicated that the sites are suitable for the proposed developments, provided that the proposed mitigation measures are properly implemented. Medium dense to dense natural sediments are present at relatively shallow depths beneath the sites, and conventional spread footing foundations would generally be used for structural support. Internal roadways and parking areas would be constructed with standard construction techniques in most areas.

Potential geotechnical impacts could result from construction-related activities, including: site preparation, structural fill placement, and foundation installation. Examples of potential adverse impacts could include sloughing of oversteepened temporary or permanent cut slopes, failure of fill soils due to improper placement and compaction, seepage from stormwater facilities which could promote landslides or erosion, or excessive foundation settlement if natural bearing sediments are disturbed. With the proposed geotechnical oversight, no adverse impacts are considered likely (see the Mitigation Measures at the end of this section and **Appendix A** for details).

Erosion Hazards Impacts

Erosion is considered to be both a long- and short-term hazard for the RRE and the Panhandle Proposed Actions, although the risks are greatest during the construction phase. Once buildings and roadways are completed and landscaping and other vegetative cover has been re-established, the risk of erosion would be similar to existing conditions. However, uncontrolled stormwater runoff from impervious surfaces (roads, roofs, driveways, patios) or from drainage conveyance systems (pipes, swales, outfalls) could still pose a risk of erosion after development, particularly on steep slopes.

In order to evaluate the impacts that the proposed projects would have on the existing three erosion hazard zones, an analysis of probable significant erosion impacts was conducted. This analysis reviewed the probable significant erosion impacts if proposed mitigation measures were not implemented in an attempt to determine the effectiveness of the proposed projects' conceptual design, and to recommend additional mitigation measures, if necessary (see **Appendix A** for further information on the erosion hazard analysis).

For both RRE and the Panhandle projects, clearing and grading activities during construction would increase the erosion potential through the removal of vegetation and the exposure of soil directly to precipitation and runoff. The most significant increase in erosion hazard potential would be during the construction phase when earthwork activity commences. Uncontrolled gully and sheet erosion along slopes or in stream channels could lead to oversteepening of the slopes and subsequent slope instability hazards. Unless otherwise mitigated, erosion would produce sediment that could then be transported to on-site wetlands and streams, and to off-site receiving waters. Uncontrolled raindrop erosion would suspend fine-grained particles into the runoff flow. Silt and clay particles, once mobilized during the earthwork activities, could be difficult to trap and could be discharged into streams through the stormwater control facilities unless additional measures are implemented. Such impacts would be effectively mitigated to non-significance by compliance with the King County Surface Water Manual (KCSWM) (1998) Temporary Erosion and Sedimentation Control (TESC) Best Management Practices (BMPs) (see the Mitigation Measures at the end of this section, and the **Water** section for details on erosion control and management of stormwater runoff during construction). With proper implementation of the proposed mitigation measures, erosion hazard impacts from the Proposed Actions can be reduced to non significant levels, even in areas where a high erosion hazard risk is present.

The construction of infiltration or unlined detention ponds could cause groundwater mounding. Where this occurs adjacent to steep slopes, new springs could form, or flow at existing springs could be increased resulting in erosion along the slopes. Erosion from these areas could enter stream channels or cause the oversteepening of slopes (i.e., to the east of the Panhandle site) and trigger landslides (see **Appendix A** for further discussion of groundwater mounding).

Stream Erosion Hazard Impacts

With development, the impervious surface areas of the sites would increase due to compaction of the ground surface by construction equipment and the construction of roads, parking areas, and buildings. Potential stream erosion hazard impacts as a result of development could include uncontrolled stormwater runoff from the impervious surface areas and stormwater facilities to the on-site drainage channels and the wetlands forming the headwaters of off-site streams. Without implementation of the proposed mitigation measures, uncontrolled stormwater runoff could increase the duration and peak flow discharges of the streams resulting in an increase in stream incision, particularly where stream channels are poorly developed. Stormwater discharge, or natural occurring high flows from storm events, can cause erosion of stream side banks and trigger landslides. Both side bank erosion and landslide activity could result in an increase in the stream bed load transport rate. An increase in sediment transport could result in the plugging of downstream culverts and related flooding. In addition, subsequent high flows could result in the erosion of previously deposited sediments and creek meandering.

Conversely, revisions to the natural drainage patterns during and after development could result in a reduction of discharge to the drainages under unmitigated conditions. A reduction of flow in the streams could also result in a buildup of sediment within the channels and lead to plugging of culverts and flooding. Fine-grained sediment could also accumulate in the channel from detention pond discharge if proper water quality treatment is not maintained, particularly during the earthwork phase of development.

It should be noted that streams are dynamic, and changes in stream morphology are a natural phenomena. It is expected that the ongoing, stream erosion and sediment transport will continue to occur in these streams regardless of development of the RRE and Panhandle sites.

To evaluate the potential for stream channel erosion with development of the RRE and Panhandle proposals, an erosion and sedimentation analysis was conducted for surface water drainages whose headwaters are formed in wetlands on the two sites (see the description of this analysis in Affected Environment). An analysis of flood-frequency data, flow durations, and storm hydrographs was conducted for Unnamed Creek (07-0276) approximately 300 feet upstream from the 243rd Avenue NE crossing, Pepper Creek and SR-5D at the confluence of Pepper Creek and SR-5D, and AC-4 at the Panhandle property boundary, to analyze potential impacts to the streams as a result of development of RRE. The results of the analysis are summarized below (see **Appendix A** for further information on the stream channel erosion analysis).

Additionally, a drainage alternative for the Panhandle, which could reduce the potential for stream channel erosion impacts, was analyzed at the direction of King County. This PSE tightline alternative, which is shown in **Figure 22** and Figure XH-010 of **Appendix C**, is not part of the applicant's proposal. Rather, it is presented as an alternative method of discharging on-site drainage from the northern portion of the Panhandle to the Snoqualmie River via a tightline currently proposed for the PSE Novelty Substation project rather than to the Pepper Creek (SRS-5) basin (see the **Water** section, Section 6.2.3 of **Appendix A**, and **Appendix C** for further description and discussion of the PSE tightline alternative).

Unnamed Creek Basin

Unnamed Creek (07-0276) and tributaries 07-0277 and 07-0277A would be susceptible to additional stream incision, sidebank destabilization, and channel degradation as a result of uncontrolled stormwater discharge from RRE (no stormwater runoff from the Panhandle site would discharge to the Unnamed Creek basin). **Table 11** summarizes the peak flows for the 1.1-, 2-, and 5-year flow events within Unnamed Creek for existing and developed conditions at the reach located about 300 feet upstream of 243rd Avenue NE. These flow events were selected because the moderate, more frequent flows move more stream bedload than the infrequent larger storms.

Table 11
UNNAMED CREEK PEAK FLOW COMPARISON
REACH UPSTREAM OF 243rd AVENUE NE

Flow Event Return Period	Existing Condition Flows (cfs)	Developed Condition Flows (cfs)	Percent change
1.1 year	2.2	2.2	0 %
2 year	3.5	3.4	-3 %
5 year	4.9	4.7	-4 %

Source: AESI, 2004 (Appendix A).
Notes: cfs = cubic feet per second

Under the RRE Proposed Action, peak flow within Unnamed Creek (07-0276) upstream of the 243rd Avenue NE crossing for flow events between the 1.1- and 5-year flow events would remain unchanged or be slightly decreased by approximately 3 to 4 percent. Storm hydrographs indicate a general overall reduction in the magnitude of the stormwater flow after development for longer recurrence interval flow events. The flow duration at this reach would be slightly reduced under developed conditions for flows above roughly 0.5 cubic feet per second (cfs).

Calculated changes in the flow of Unnamed Creek (07-0276) of less than 10 percent would likely not be discernable from the natural variations exhibited by the creek under existing conditions, provided that the overall hydrograph is maintained, due to the margin of error in modeling and natural variability of stream flow. In most cases, a stream that is at equilibrium could experience channel aggradation by a decrease in peak flow. However, in this case, as for Pepper Creek and AC-4, Unnamed Creek is not considered to be in equilibrium, as evidenced by numerous landslides and other erosion features. Because the Unnamed Creek basin is located within a landslide hazard area drainage basin, and due to the ongoing erosion under existing conditions, the calculated decrease in peak flows would not be considered an adverse impact (see **Appendix A** for further discussion).

Pepper Creek Basin

Pepper Creek (SR-5) and tributaries SR-5A and SR-5D would be susceptible to additional stream incision, sidebank destabilization, and channel degradation as a result of uncontrolled stormwater discharge. Under the RRE Proposed Action, stormwater runoff to the Pepper Creek basin would either be discharged via dispersal methods to proposed sensitive area tracts containing wetlands or to the proposed infiltration facility. Stormwater runoff to the Pepper Creek (SR-5) and SR-5D basins from cleared areas proposed within the Panhandle (subbasins SRS-2 and SRS-3) would be directed to two stormwater detention facilities. Stormwater runoff from cleared areas within the SRS-4 subbasin, which under existing conditions would discharge as interflow or sheet flow to the steep slopes above the Snoqualmie River Valley, would also be collected and routed to a stormwater detention facility within the SR-5D basin (subbasin SRS-3) (stormwater management is described in more detail in the **Water** section and **Chapter 2** for additional details).

An analysis of flood-frequency distributions, flow durations, and storm hydrographs was conducted for Pepper Creek (SR-5) and SR-5D to analyze potential impacts to the stream as a result of development of the RRE and Panhandle sites (see Appendix 9 in **Appendix A**). The modeled reach examined as part of the analysis was located about 400 feet north of the RRE and Panhandle sites at the confluence of Pepper Creek (SR-5) and SR-5D. **Table 11a** summarizes the peak flows for the 1.1-, 2-, and 5-year flow events within Pepper Creek for existing and developed conditions at the reach located at the confluence with SR-5D with development of both the RRE and Panhandle sites. These flow events were selected since the moderate, more frequent flows typically move more bedload than the infrequent larger storms (as discussed in the introduction to this section).

Under the Proposed Actions for the RRE and Panhandle sites, peak flow within Pepper Creek (SR-5) at the confluence with SR-5D for flow events between the 1.1- and 5-year flow events would be decreased by approximately 8 to 17 percent. Storm hydrographs indicate a general overall reduction in the magnitude of peak storm flow after development for longer recurrence

Table 11a
PEPPER CREEK PEAK FLOW COMPARISON
REACH AT PEPPER CREEK/SR-5D CONFLUENCE

Flow event Return Period	Existing Condition Flow (cfs)	Developed Condition Flow (cfs)	Equivalent Existing Condition Return Period	Percent change
1.1 year	5.1	4.7	1.05 to 1.1 year	-8 %
2 year	9.7	8.3	1.6 year	-14 %
5 year	16.6	13.7	3.1 year	-17 %

Source: AESI, 2004.
cfs = cubic feet per second

interval flow events. For the Proposed Actions, the flow durations at this reach would be reduced under developed conditions for flows at or above roughly 1.5 cfs. As described for Unnamed Creek, calculated changes in the flow of Pepper Creek (SR-5) of less than 10 percent would likely not be discernable from the natural variations exhibited by the creek under existing conditions, provided that the overall hydrograph is maintained, due to the margin of error in modeling and natural variability of stream flow. Because the Pepper Creek basin is located within a landslide hazard area drainage basin, and due to the ongoing erosion under existing conditions, the calculated decrease in peak flows is not considered to be an adverse impact. Analysis by King County indicates that there is a potential for significant adverse impacts from the applicant's current proposal.

PSE Tightline Alternative. As described previously, the PSE tightline alternative (analyzed at the direction of King County and not part of the Proposed Action) would convey stormwater drainage from the northern portion of the Panhandle site to the Snoqualmie River, removing a portion of flows from SR-5 (Pepper Creek) and SR-5D (Pepper Creek tributary). The increase in flow duration for flows of less than 1.5 cfs in the Pepper Creek basin (at the confluence of Pepper Creek [SR-5] and SR-5D), described for the Proposed Action, would be reduced with the PSE tightline alternative, and flow durations for even these low flows would likely be less than existing conditions. Although the Proposed Action would protect stream erosion in Pepper Creek by reducing peak flows and flow durations for flows of 1.5 cfs or higher, the PSE tightline alternative would further reduce peak flows, flow durations and volumes leaving the Panhandle site (see the **Water** section, Section 6.2.3 of **Appendix A**, and **Appendix C** for further discussion of the PSE tightline alternative).

Ames Creek Tributaries

AC-2 and AC-2A. Subbasin AC-2 on the Panhandle site drains overland to the AC-2 and AC-2A basin. However, Ames Creek tributaries AC-2 and AC-2A do not receive any direct surface water runoff under existing conditions from the Panhandle site. AC-2 and AC-2A begin approximately 200 to 300 feet down slope from the eastern boundary of the Panhandle site at a spring discharge zone from a pre-Possession-age aquifer. Impacts to aquifers are discussed in the **Water** section and in **Appendix A**.

Under the Panhandle proposal, stormwater runoff from proposed cleared areas within subbasin AC-2 would be directed to individual lot infiltration systems. Stormwater management for this basin is described in more detail in **Appendix A**. No stormwater would directly discharge into either AC-2 or AC-2A. Therefore, stormwater runoff from the Panhandle development would not be expected to increase landslide or erosion in these streams.

AC-4. Ames Creek tributary AC-4 would be susceptible to stream incision, sidebank destabilization, and channel degradation as a result of uncontrolled stormwater discharge. Stormwater runoff to AC-4 basin from cleared areas within the Panhandle portion of the development (subbasin AC-1) would be primarily directed to two stormwater detention facilities. One lot within this subbasin would have a single lot infiltration system. Both facilities would ultimately discharge to Wetland VS-12 (headwaters of AC-4) (stormwater management is described in more detail in **Chapter 2** and the **Water** section and **Appendix C**).

An analysis of flood-frequency distributions, flow durations, and storm hydrographs was conducted for AC-4 to analyze potential impacts to the stream as a result of development of the Panhandle site (Appendix 9 in **Appendix A**). The modeled reach examined as part of the analysis was located at the southern Panhandle boundary at the outlet of wetland VS-12 (headwaters to AC-4).

Table 11b summarizes the peak flows for the 1.1-, 2-, and 5-year flow events within AC-4 for existing and developed conditions at the reach located at the property boundary. These flow events were selected since the moderate, more frequent flows move more bedload than the infrequent larger storms (as discussed in the introduction to this section).

Table 11b
AC-4 PEAK FLOW COMPARISON
REACH AT VS-12 OUTLET/PROPERTY BOUNDARY

Flow event Return Period	Existing Condition Flow (cfs)	Developed Condition Flow (cfs)	Equivalent Existing Condition Return Period	Percent change
1.1 year	0.6	0.6	1.1 year	0 %
2 year	1.3	1.1	1.5 year	-15 %
5 year	2.3	1.8	3 year	-22 %

Source: AESI, 2004.
cfs = cubic feet per second

Under the Proposed Action for the Panhandle site, peak flow within AC-4 at the property boundary for flow events between the 1.1- and 5-year flow events would remain unchanged or be decreased by approximately 15 to 22 percent. Storm hydrographs indicate a general overall reduction in the magnitude of the storm flow after development for longer recurrence interval flow events. For the Proposed Action, the flow durations at this reach would be reduced under developed conditions for flows at or above roughly 0.3 cfs. Because the AC-4 tributary basin is located within a landslide hazard area drainage basin, and due to the ongoing erosion under existing conditions occurring downstream of the 258th Avenue NE crossing, the calculated decrease in peak flows is not considered to be an adverse impact.

On-Site Streams

The intermittent on-site streams, include the entire length of BBC 52 tributary, BBC 53 tributary, and HH/BBC 54 tributary, a portion of VS 17 tributary, and potentially small portions of VS 24 tributary and EE/VS 31 tributary (see **Figure 2** for a depiction of the streams). These streams are formed by wetland discharge, and would be susceptible to erosion as a result of uncontrolled stormwater runoff. Impacts to wetlands and downstream drainage systems from the proposed developments, and the performance of the proposed stormwater control facilities, were evaluated against a variety of wetland, flow rate, duration and volume performance criteria using the HSPF model. The post-development wetland hydrology was evaluated against the King County Wetland Hydrology Management Guidelines (Sensitive Area Mitigation Guidelines, Appendix A, 5/29/03). These guidelines incorporate wetland water level and excursion guidelines form the Puget Sound Wetlands and Stormwater Management Research Program (see Section VII of **Appendix C** for further explanation and results of the analysis; see the **Wetlands** section and **Appendix F** for assessment of wetland impacts). Under the proposals, these streams would be buffered or located within wetland buffers/sensitive area tracts. No direct discharge is proposed to any on-site streams and the existing wetland hydrology would be maintained following development. Therefore, stormwater runoff from the RRE and Panhandle developments would not be expected to increase landslides and erosion in the on-site streams.

Landslide Hazards

Sloping ground has an inherent risk of instability. In some cases, due to low-slope gradients and geologic and hydrologic conditions, the landslide risks may be considered low. The risk is greater where ongoing or historic landslide activity has occurred. Landslides are natural occurring phenomena; however, the risk of a landslide could be increased as a result of land development.

In order to evaluate the impacts that the proposed projects would have on the existing landslide hazard zones (see **Figure 18**), an analysis of potential landslide impacts was conducted. This analysis reviewed the probable significant impacts if mitigation measures were not implemented in an attempt to determine the effectiveness of the proposed projects' design and to recommend additional measures, if necessary. From this analysis, landslide impacts from and to the proposed projects were considered to be possible under three primary activities. These include: 1) stormwater management, 2) clearing, and 3) grading (earthwork), as described below.

Stormwater from the RRE and Panhandle sites would be directed to detention or infiltration facilities. Detention facilities on the RRE site would release treated stormwater into adjacent, off-site wetlands or the Unnamed Creek high flow bypass line that discharges into the Snoqualmie River. Under unmitigated conditions, groundwater mounding could occur under the proposed infiltration facility (SRS-1 No. 1 on the RRE site), or in some cases beneath unlined detention ponds. Both detention pond SRN-2 No. 1 and infiltration pond SRS-1 No. 1 could increase the existing landslide hazard risks by creating a higher, localized groundwater table.

The groundwater table could recharge slopes and trigger slope instability resulting in impacts to the ravines or to rural development along the streams to the east of the Panhandle site. Under the Proposed Actions, detention ponds excavated into Vashon advance outwash would be lined, and the large infiltration facility on the RRE site would be sited to avoid impacts to slopes (see **Appendix A** for details). Five on-site stormwater infiltration systems are proposed for the Panhandle. The systems would be located on the downslope portions of Lots 8, 18, 19, 20 and 21 on the easternmost portion of the Panhandle, approximately 100 to 500 feet from the top of Landslide Hazard Zone 2. The primary concern related to stormwater infiltration from these lots is the potential for adverse impacts to offsite steep slopes. However, existing geologic conditions (including extensive storage capacity for stormwater infiltration in the unsaturated interval of pre-Possession-age sand), the location of infiltration facilities, and the volume of runoff would reduce the potential for adverse impacts. Additionally, groundwater mounding and slope stability analyses were performed to evaluate potential impacts from the single-lot infiltration facilities. The groundwater mounding analyses showed no measurable impact when infiltrating the worst water year on record for the largest of the 5 lots. Therefore, no adverse impacts to stability of off-site steep slopes are expected from operation of the proposed detention and infiltration facilities (see **Appendix A** for further discussion). Specific geotechnical engineering recommendations would be incorporated into the final design of the detention and infiltration ponds in order to prevent groundwater mounding and slope instability.

Under the Panhandle proposal, uncontrolled clearing could increase the existing landslide hazard potential of Landslide Hazard Zone 2 by removing the vegetation that would normally reduce the runoff volume and rates. Concentrated stormwater runoff on cleared slopes could precipitate erosion and oversteepening of the hillside and result in slope instability. The steep slope area on the Panhandle site would be placed in a sensitive areas tract and no clearing would be permitted in this area. A 100-foot wide building setback and buffer is also proposed from the top of slope in this area for stormwater dispersion that would further reduce potential landslide hazards. KCC 21A.24.280 requires a 50-foot landslide hazard/steep slope buffer from the top of the slope. The required building setback is 50 feet from the buffer for landslide hazards that are also steep slope hazards, for a total of 100 feet. KCC allows reduction of the building setback to 15 feet from the buffer if based on a special study approved by King County. The current proposal does not preclude application for steep slope building setback reduction at the time of development. Based on existing geology and groundwater conditions, this buffer would be wide enough to avoid the creation of landslide hazards. No Landslide Hazard Zone 2 areas are located on the RRE site. Clearing of the Panhandle site would be limited to approximately 35 percent of the total unsubmerged site area, with a maximum 20 percent impervious surface are per lot. A homeowners association or other regulatory authority would enforce CC&Rs, including clearing limitations and implementation of an approved vegetation management plan.

For both RRE and the Panhandle, uncontrolled grading (earthwork) activities could also increase the existing landslide hazard risks. For the Panhandle, fill soils placed on or adjacent to steep slopes might increase the driving forces of the soil column and result in slope failures. Grading typically alters surface drainage patterns. In addition, improperly placed fill soils could fail due to inadequate compaction of soils; use of organic material or soft, fine-grained soils; placement of material at oversteepened gradients; or, other factors. Cut slopes could also fail due to removing the toe support for a slope, or from improper drainage control. On both RRE and the Panhandle, if the new drainage pattern resulted in an increase in either surface or subsurface water flow on or near a slope, landslides could develop. Provided that proposed mitigation measures to address potential impacts from clearing and grading activities are implemented, including implementation of proposed CC&Rs regarding allowed clearing, the Proposed Actions would not increase the existing landslide hazard risks on or immediately adjacent to the sites.

Seismic Hazards Impacts

The effects of an earthquake can result in more damage in areas which are converted from an undeveloped condition to a more developed condition, thereby increasing the risk of seismic hazards. As described previously, the project sites are located in an area of relatively low historical seismicity. The hazards associated with seismic events felt at the RRE and Panhandle sites include surface ground rupture, ground motion, liquefaction, and seismically induced landslides.

Surface Ground Rupture. No evidence of surface ground rupture was observed on the sites. Therefore, the potential for a ground surface rupture impacting the project sites as a result of seismic activity is low and no mitigation would be required.

Ground Motion. Large earthquakes with magnitudes of up to magnitude 7.1 have occurred in the Puget Sound in the past. Significant ground motion caused by an earthquake of sufficient intensity could result in damage to buildings, roadways, and other structures including utilities. If the UBC is followed, buildings would be designed to be able to sustain some damage from ground motion during the design seismic event without causing life safety concerns.

Liquefaction. Soils susceptible to liquefaction during larger seismic events may be present in areas of the sites underlain by shallow, saturated cohesionless soils, such as soils underlying wetland areas and streams. However, the liquefiable soils are likely relatively thin, and likely do not extend beyond the limits of delineated buffer zones which encompass individual wetlands and stream corridors. By far, the majority of the natural sediments on the sites are considered to possess a low potential for liquefaction and no potential adverse impacts have been identified.

Seismically Induced Landslides. Areas prone to seismically induced landslides would probably correspond to Landslide Hazard Zone 2 (present on the Panhandle site) with or without development. No Landslide Hazard Zone 2 areas are present on the RRE site. A seismic event of significant local intensity might function as a trigger mechanism for landslides and debris flows to occur on the easternmost portion of the Panhandle site and adjacent off-site areas designated as Landslide Hazard Zone 2 (see **Figure 18**).

Cumulative Impacts

Cumulative earth-related impacts would primarily be associated with the potential for increased erosion and subsequent sedimentation of water resources on the RRE and Panhandle sites and in the vicinity of the sites. Erosion potential would be the greatest during construction when ground surfaces would be exposed. RRE and the Panhandle would implement temporary erosion and sedimentation control measures consistent with Best Management Practices outlined in the KCSWM (1998). Therefore, no significant erosion-related impacts would be anticipated during construction of RRE and the Panhandle. No other earth-related cumulative impacts would occur (see **Appendix A** for additional information on cumulative earth impacts).

Access Alternatives

Construction of all for all of the access alternatives would require clearing and grading to achieve desired roadway elevations. Preliminary plans indicate that approximately 24,200 cubic yards of earthwork (cut/fill and stripping) would be required for Alternative A, 12,725 cubic yards for Alternative B, 25,850 cubic yards for Alternative C and 54,535 cubic yards for Alternative C-1, based on the assumed roadway designs. The potential for erosion and subsequent sedimentation impacts with all of the alternatives would be greatest during construction when soils are exposed. Based on the locations and soils conditions of the sites for the roadways, the potential for erosion during and following construction would be minimal (see the **Water** section for a discussion of the potential for sedimentation impacts with the access alternatives). See **Appendix I** for further discussion of the earth-related impacts of the alternatives.

ALTERNATIVES

Alternative 1 – 5-acre Rural Development

Under Alternative 1, less clearing, grading, impervious surface areas and stormwater runoff are anticipated than under the Proposed Actions. Impacts associated with clearing and grading and stormwater runoff (i.e., erosion and subsequent sedimentation of surface water resources on the sites and in the vicinity of the sites) would likely be less than under the Proposed Actions. Under Alternative 1, clearing, grading, impervious surface areas and stormwater runoff on the Panhandle site would be similar to under the Panhandle proposal and earth-related impacts would be expected to be similar as well. As under the Proposed Actions, Alternative 1 would implement the TESC BMPs from the KCSWM (1998) to address potential erosion and landslide hazard impacts. Under this alternative, it is not likely that an infiltration pond would be constructed on the RRE site. Detention ponds could be required, with their associated potential for groundwater mounding.

Potential stream erosion hazards under Alternative 1 would likely be less than under the Proposed Actions because less stormwater runoff from impervious surface areas would be generated under this alternative. Under Alternative 1, coordinated stormwater controls and related stream erosion protection may not be provided if the sites are developed as a series of short plats; more coordination would result if the sites were developed as a rural plat. However, development under this alternative would implement TESC BMPs from the KCSWM (1998), which would reduce the potential for stream erosion hazard impacts. Adherence to King County Codes and KCSWDM criteria would also be required if this alternative were pursued. It is likely that, due to proximity of steep slopes, a tightline for stormwater conveyance would be required under several options for sequencing development on either the RRE or Panhandle sites.

The potential for seismic hazard impacts under Alternative 1 would be same as described under the Proposed Actions.

Alternative 2 – No Action

Under Alternative 2, no development would occur on the sites and earth-related conditions, including natural erosion and landslide activity, would continue as described in the Affected Environment section. The 20 tax-lots on the RRE and Panhandle properties could be sold and individual homes built on each lot. Under Alternative 2, less clearing, grading, impervious surface areas and stormwater runoff are anticipated than under the Proposed Actions and

Alternative 1. Impacts associated with clearing and grading and stormwater runoff (i.e., erosion and subsequent sedimentation of surface water resources on the sites and in the vicinity of the sites) would likely be less than under the Proposed Actions and Alternative 1 as well. Vehicular and pedestrian circulation and treatment of wetlands and other sensitive areas would also likely be uncoordinated if the sites are developed as a series of short plats; more coordination would result if the sites were developed as a rural plat. With future development, stormwater would likely be controlled using dispersal methods

Potential stream erosion hazards under Alternative 2 would likely be less than under the Proposed Actions and Alternative 1 because less stormwater runoff from impervious surface areas would be generated under this alternative.

Because of the anticipated larger parcel sizes under Alternative 2, relative to under the Proposed Actions and Alternative 1, sufficient area would be available to construct residences within the lower geotechnical hazard zones. Setbacks from slopes, construction of retaining walls, and regrading could also be more easily accomplished. Adherence to King County Codes and KCSWDM criteria would also be required if this alternative were pursued, and a tightline for stormwater conveyance could be required on either the RRE or Panhandle sites, depending on how the sites are developed.

The potential for seismic hazard impacts under Alternative 2 would be same as described under the Proposed Action.

MITIGATION MEASURES

Required/Proposed

During Construction

Redmond Ridge East and Panhandle

- To reduce the sheet and channel erosion hazard potential on the sites, the projects would employ Best Management Practices (BMPs) outlined in the KCSWM (1998). Per these guidelines, the following BMPs would be implemented during construction. Specific BMPs to be implemented during construction would be outlined in the geotechnical engineering report and temporary erosion and sediment control (TESC) plans to be prepared during engineering design.

  -- TESC measures would commence at the same time as the clearing activities and be operating properly prior to beginning grading activities.
  -- Clearing limits would be clearly marked on plans and in the field.
  -- Major earthwork construction activities would generally be limited to avoid October 1 through April 30 (the wet season as identified in KCC 16.82.150(D)); no work would occur during that time unless approved by King County per the exceptions and allowances described in KCC 16.82.150(D). Clearing within erosion hazard areas would occur only between April 1 and September 1, consistent with KCC 21A.24.220.
  -- Temporary construction entrances and staging areas would be stabilized with quarry spall or equipped with wheel washing facilities.
  -- Road cleaning (i.e., shoveling or sweeping sediment followed by street sweeping) would occur on a daily basis.

-- Cover materials would be placed on exposed ground surfaces within 12 hours of exposure. Cover materials would include: straw mulch, plastic sheeting, grass, rolled erosion blankets, and clean crushed rock. During the wet season, the exposed subgrade would be mulched and seeded, covered with plastic sheeting, or otherwise protected by an erosion method approved by the erosion control inspector.
-- Exposed construction slopes would be trackwalked (up and down) in order to roughen the ground surface and reduce runoff velocities.
-- Surface water runoff would be directed away from exposed subgrades or into approved temporary or permanent stormwater conveyance systems, such as pipes or rock-lined swales.
-- Stockpiled soils to be used as backfill material would be stored in a manner that would minimize sheet erosion, rilling, or gully erosion. Protective measures may include, but are not necessarily limited to, covering the stockpiled soils with plastic sheeting, the use of low stockpiles in flat areas, or the use of silt fences around the perimeter of the stockpiles.
-- Temporary sedimentation traps or ponds would be installed to control sediment transport during construction. The permanent water quality pond may be used as the temporary sediment pond unless the permanent pond is an infiltration facility. The permanent detention facilities must be cleaned of all accumulated sediment after the completion of construction activities.
-- Rock check dams would be established, as necessary, along roadways and within drainage ditches constructed along sloping ground to reduce the water energy and the subsequent risk of channel incision.
-- Silt fences would be established along wetlands, streams, open space areas, and other sensitive areas located in or adjacent to construction zones to reduce the risk of sediment transport into these features.
-- Discharge points for stormwater release, including emergency overflow outfalls, would be provided with an energy dissipater to reduce the risk of erosion. These features may consist of gabion blocks, concrete aprons, or riprap. Site-specific studies may be required to locate the exact discharge points and the type of erosion measure to be employed.
-- All turbid construction runoff would be collected and treated by sediment ponds, sand filters, temporary filtration, or other approved methods before release to any surface waters. Surface discharge would not exceed 5 nephelometric turbidity units (NTU) above background in the receiving water and be free of construction waste or its influences.
-- As part of construction phasing, stormwater detention ponds would be constructed during the initial phase of construction.
-- Clean water would not be allowed to enter construction areas or mix with construction water. All intercepted clean water would either be routed around construction areas to discharge into the original receiving waters or discharge separately into stormwater facilities. Energy dissipaters may be required at discharge points depending on the site conditions.
-- An erosion control inspector would be on site during construction to assist in maintaining the integrity of the erosion control structures and to provide further site-specific erosion recommendations, as necessary.
-- Surface water and domestic discharge, either during or after construction, would not be directed onto sloping areas or randomly daylight on the sites. All temporary or permanent devices used to collect surface runoff would be directed into tightlined systems that discharge into approved stormwater control facilities.

-- The geotechnical engineer would review the grading, erosion, and drainage plans prior to final plan design to recommend additional measures to address erosion hazards during development, as necessary.

- To address the potential for landslides, the following BMPs would be implemented:

  -- A geotechnical engineer would review all grading, erosion, and drainage control plans prior to construction and throughout the construction phase to assist in reducing the landslide hazard risks from and to the development.
  -- Construction slopes would be determined by the contractor during construction (see **Appendix A** for estimates of temporary unsupported cut slopes in various soil conditions and further detail on recommended site preparation activities).
  -- The contractor would use care during site preparation and excavation operations so that the underlying soils (i.e. the lodgment till soils) are not softened.
  -- Access and staging areas would be protected with an appropriate section of crushed rock or Asphalt Treated Base (ATB).
  -- Permanent cut slope angles would be determined once the specific design process is undertaken.
  -- Proposed fill soils would be evaluated by the geotechnical engineer prior to their use in fills. (Specific provisions for the use of structural fill are detailed in **Appendix A**).

- Spread footings would be used for building support when founded on medium dense to dense natural soils or structural fill placed according to the provisions detailed in **Appendix A**. All footings would penetrate to the prescribed bearing stratum and no footing would be founded in or above loose, organic or existing fill soils. Allowable foundation soil bearing pressures would be determined once detailed engineering plans are prepared.

- Specific geotechnical engineering recommendations would be incorporated into the final design of the detention ponds/sand filters. These facilities would be constructed to restrict seepage potential, including measures such as: clay liners; geosynthetic liners; scarification and recompaction in fine-grained soils; and, geotechnical design of any berms. Additional measures may be identified by the geotechnical engineer as design plans are finalized.

- Detention ponds excavated into Vashon advance outwash would be lined (see **Appendix A** for details).

Redmond Ridge East

- To mitigate and reduce the erosion or landslide hazard potential, the following measures would be implemented:

  -- Site-specific geotechnical recommendations for detention and infiltration ponds would be made at the time of plat-level design (see **Appendix C** for preliminary designs of the detention and infiltration ponds).
  -- All stormwater runoff from RRE would be either directed into tightlined systems that discharge into approved stormwater facilities or dispersed into native/forested buffers. Erosion control measures as outlined in this report would also apply for all discharge points.
  -- Geotechnical criteria would be established for the use of the proposed select borrow site (located in the recreation complex area) and on-site fill zone for construction to address:

1) establishing stable excavation sidewalls and appropriate setback limits from buildings, roadways and other structures; 2) controlling groundwater seepage from zones of perched water in the lodgment till; and 3) development of acceptable settlement mitigation criteria with respect to future use of the borrow site.

-- Specific recommendations for the borrow site regarding pit excavation and surface drainage, safety, settlement evaluation and mitigation, backfill, surcharge, and final grading would be developed during engineering design when borrow pit configurations are proposed.

Panhandle

- To address the potential for erosion or landslides, the following BMPs would be implemented:

-- The isolated Erosion Hazard Zone 2 area in the center of Lot 18 on the Panhandle site (**Figure 12**) would be specifically delineated in the field prior to construction. The isolated area may be graded out to a lesser slope during construction. Plans would be reviewed by the geotechnical engineer during the design process to evaluate the erosion risks, slope instability risks, and to provide specific mitigation recommendations designed to minimize erosion hazard potential.

-- Site-specific studies would be performed as part of the plat-design process to determine building setback distances from Landslide Hazard Zone 2. King County's current building setback distance is a 50-foot buffer plus an additional 50-foot building setback for a total of 100 feet. KCC 21A.24.280A allows for a reduction of the building setback to a minimum of 15 feet if the County determines that the reduction will adequately protect a development project and the sensitive area. A 100-foot stormwater building setback/buffer dispersion zone is currently proposed. The proposed Panhandle plans show a 50-foot setback from a 50-foot steep slope buffer, for a total setback of 100 feet. This setback could be revised (reduced) if future geotechnical investigations during plat design indicate that a reduction in setback would not adversely impact landslide hazards.

-- All stormwater runoff from the Panhandle would be directed into on-site collection and conveyance facilities that discharge into approved stormwater ponds or a limited number of individual lot infiltration facilities. Controlled discharges from the on-site pond facilities are proposed to be dispersed into native/forested sensitive area buffers upstream of existing wetlands. Erosion control measures as outlined in **Appendix A** would also apply for all discharge points.

-- No fill, topsoil, or other debris would be placed over the top of Landslide Zone 2. Any fill planned for slopes steeper than 5H:1V (Horizontal:Vertical) would be benched and compacted into the hillside per the geotechnical engineer's recommendations. Depending on the proposed slope gradients, the use of retaining or erosion control structures may be required in these areas.

-- No cuts would be made on or at the toe of Landslide Hazard Zone 2 unless approved by the geotechnical engineer. Any proposed cuts elsewhere on the project site would also be reviewed by the geotechnical engineer during the design process to evaluate the risk of slope instability and to provide specific mitigation recommendations designed to minimize landslide hazard potential.

-- No vegetation would be removed from Landslide Hazard Zone 2, with the exception of hazard trees and clearing activities permitted by KCC 21A.24. Vegetation removed from elsewhere on the site would follow the recommendations for erosion presented in **Appendix A**.

- Site-specific geotechnical recommendations for roof and septic field infiltration would be made at the time of plat-level design.

- All buildings would be designed per the UBC standards for Seismic Zone 3.

- Clearing of the Panhandle site would be limited to approximately 35 percent of the total unsubmerged site area, with a maximum 20 percent impervious surface are per lot. A homeowners association or other regulatory authority would enforce CC&Rs, including clearing limitations and implementation of an approved vegetation management plan.

Following Construction

- Surface water and domestic discharge from the RRE and Panhandle sites, either during or after construction, would not be directed onto sloping areas or randomly daylight on the site. All temporary or permanent devices used to collect surface runoff would be directed into tightlined systems that discharge into approved stormwater control facilities.

- Stormwater from the Panhandle site would be dispersed into on-site native/forested buffers away from the top of Landslide Hazard Zone 2. All stormwater runoff from RRE would be either directed into pipe systems that discharge into approved stormwater facilities or dispersed into native/forested buffers. Erosion control measures as outlined in **Appendix A** would also apply for all discharge points.

- Landscaping established on the sites with development would help to minimize post construction erosion.

SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

During construction, soils would be exposed to erosion, which would result in increased potential for sedimentation of receiving waters. Implementation of the required/proposed mitigation measures would effectively limit adverse impacts associated with stormwater runoff during construction. Consequently, no significant unavoidable adverse earth-related impacts are anticipated.